

Exhibit B

Hectorite

From Wikipedia, the free encyclopedia

Hectorite is a soft, greasy clay mineral that forms near Hector, California (in San Bernardino County). The mineral is rare in that it is found primarily in one mine. **The chemical composition of hectorite includes: sodium, lithium, magnesium, silicon, hydrogen and oxygen.** Hectorite is mostly used in the manufacturing of cosmetics, but has uses in chemical and other industrial applications.

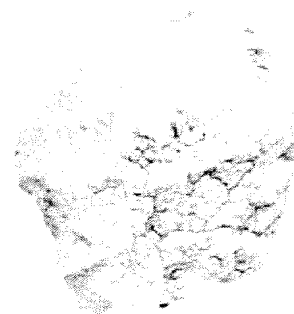
Hectorite occurs with bentonite as an alteration product of clinoptilolite from volcanic ash and tuff with a high glass content.^[1]

References

- ^{a b} <http://rruff.geo.arizona.edu/doclib/hom/hectorite.pdf> Handbook of Mineralogy
- ^a "Hectorite Mineral Data" Mineralogy Database. <<http://webmineral.com/data/Hectorite.shtml>
- ^a Ralph, Jololyn and Ida (2007): "Hectorite" Mineral information and data. Mineralogy Database. <http://www.mindat.org/min-1841.html>

Retrieved from "<http://en.wikipedia.org/wiki/Hectorite>"

Hectorite



Hectorite from California

General	
Category	Mineral
Chemical formula	$\text{Na}_{0.4}\text{Mg}_{2.7}\text{Li}_{0.3}\text{Si}_4\text{O}_{10}(\text{OH})_2$
Identification	
Color	White
Crystal habit	Thin laths and aggregates
Crystal system	Monoclinic
Cleavage	[001] Perfect
Fracture	Uneven
Mohs Scale hardness	1 - 2
Luster	Earthy (dull)
Refractive index	$n_\alpha = 1.490$ $n_\beta = 1.500$ $n_\gamma = 1.520$
Optical Properties	Biaxial - 2V small
Birefringence	$\delta = 0.030$ max.
Pleochroism	Colorless
Streak	White
Specific gravity	2-3 (Avg 2.5)

- This page was last modified 10:07, 14 November 2007.
- All text is available under the terms of the GNU Free Documentation License. (See **Copyrights** for details.) Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a U.S. registered 501(c)(3) tax-deductible nonprofit charity.

Hectorite

Mineral Data +

Pronunciation



[\[Newest Minerals\]](#) [\[Rare Minerals\]](#) [\[Cabinet Specimens\]](#) [\[About Us\]](#) [\[Image Gallery\]](#)

Dakota Matrix Minerals

Updated weekly, for the collector, educator, and researcher since 1996

Extensive Inventory of very Rare Minerals. Visa and Mastercard are Welcome

General Hectorite Information

Chemical Formula: $\text{Na}_{0.3}(\text{Mg},\text{Li})_3\text{Si}_4\text{O}_{10}(\text{OH})_2$

Composition: Molecular Weight = 383.25 gm

<u>Sodium</u>	2.40 %	Na	3.23 %	Na_2O
<u>Lithium</u>	0.54 %	Li	1.17 %	Li_2O
<u>Magnesium</u>	17.12 %	Mg	28.39 %	MgO
<u>Silicon</u>	29.31 %	Si	62.71 %	SiO_2
<u>Hydrogen</u>	0.53 %	H	4.70 %	H_2O
<u>Oxygen</u>	50.10 %	O		

100.00 %

100.21 % = TOTAL OXIDE

Empirical Formula: $\text{Na}_{0.4}\text{Mg}_{2.7}\text{Li}_{0.3}\text{Si}_4\text{O}_{10}(\text{OH})_2$

Environment: Clay mineral from altered volcanic tuff ash with a high silica content related to hot spring activity. Smectite group mineral.

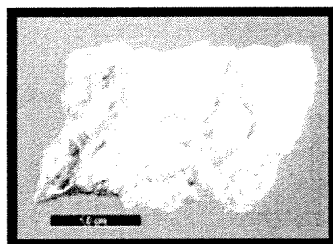
IMA Status: Valid Species (Pre-IMA) 1936

Locality: Company No. 1 mine, 3 miles south of Hector, San Bernardino Co., California. Link to [MinDat.org](#) Location Data.

Name Origin: Named after it's locality.

Hectorite Image

Images:



Hectorite

Comments: Pure white paper-like matted masses of hectorite.

Location: near Hector, San Bernardino County, California, USA. **Scale:** See Photo.

© Jeff Weissman / Photographic Guide to Mineral Species

Hectorite Crystallography

Axial Ratios: $a:b:c = 0.5718:1:1.7429$

Cell Dimensions: $a = 5.25$, $b = 9.18$, $c = 16$, $Z = 3$; $\beta = 99^\circ$ $V = 761.63$
 $\text{Den(Calc)} = 2.51$

- ? **Crystal System:** **Monoclinic - Prismatic** H-M Symbol (2/m) Space Group: C 2/m
 ? **X Ray Diffraction:** By Intensity(I/I_0): 1.53(1), 4.58(1), 15.8(0.8),

Physical Properties of Hectorite

- ? **Cleavage:** [001] Perfect
 ? **Color:** White.
 ? **Density:** 2 - 3, Average = 2.5
 ? **Diaphaniety:** Translucent to Opaque
 ? **Fracture:** Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern.
 ? **Habit:** Aggregates - Made of numerous individual crystals or clusters.
 ? **Hardness:** 1-2 - Between Talc and Gypsum
 ? **Luminescence:** Fluorescent.
 ? **Luster:** Earthy (Dull)
 ? **Streak:** white

Optical Properties of Hectorite

- ? **Gladstone-Dale:** $CI_{meas} = 0.055$ (Good) - where the $CI = (1 - K_{PDmeas}/KC)$
 $CI_{calc} = 0.058$ (Good) - where the $CI = (1 - K_{PDcalc}/KC)$
 $K_{PDcalc} = 0.2005, K_{PDmeas} = 0.2013, KC = 0.2129$
 ? **Optical Data:** Biaxial (-), $a = 1.49$, $b = 1.5$, $g = 1.52$, $bire = 0.0300$
 ? **Pleochroism (x):** colorless.
 ? **Pleochroism (y):** colorless.
 ? **Pleochroism (z):** colorless.

Calculated Properties of Hectorite

- ? **Electron Density:** $\rho_{electron} = 2.50$ gm/cc
 note: $\rho_{Hectorite} = 2.50$ gm/cc.
 ? **Fermion Index** Fermion Index = 0.03146
 Boson Index = 0.96854
 ? **Photoelectric:** $PE_{Hectorite} = 1.56$ barns/electron
 $U = PE_{Hectorite} \times \rho_{electron} = 3.89$ barns/cc.
 ? **Radioactivity:** $GR_{api} = 0$ (Gamma Ray American Petroleum Institute Units)

Hectorite is **Not Radioactive**

Hectorite Classification

- ? **Dana Class:** **71.3.1b.4** (71) Phyllosilicate Sheets of Six-Membered Rings (71.3) with 2:1 clays
 (71.3.1b) Smectite group (Trioctahedral Smectites)
 71.3.1b.1 Sobotkite? $(K,Ca_{0.5})_{0.33}(Mg,Al)_3(Si_3Al)O_{10}(OH)_2 \cdot 1-5(H_2O)$ Unk., Mono
 71.3.1b.2 Saponite $(Ca/2,Na)_0.3(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4(H_2O)$ C 2/m 2/m

71.3.1b.2a Ferrosaponite! $\text{Ca}_0.3(\text{Fe},\text{Mg},\text{Fe})_3(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ C? Mono
 71.3.1b.3 Sauconite $\text{Na}_0.3\text{Zn}_3(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ C 2/m 2/m
 71.3.1b.4 Hectorite $\text{Na}_0.3(\text{Mg},\text{Li})_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ C 2/m 2/m
 71.3.1b.5 Pimelite $\text{Ni}_3\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ Unk. Hex
 71.3.1b.6 Stevensite $(\text{Ca}_0.5,\text{Na})_0.33(\text{Mg},\text{Fe})_3\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n(\text{H}_2\text{O})$ Unk (ORTH ?) Mono
 71.3.1b.7 Yakhontovite $(\text{Ca},\text{K})_0.5(\text{Cu},\text{Fe},\text{Mg})_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot 3(\text{H}_2\text{O})$ C 2/m 2/m
 71.3.1b.8 Zincsilite $\text{Zn}_3\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ (?) C 2/m ? 2/m

Strunz Class:**VIII/H.20-10 VIII - Silicates**

VIII/H - Phyllosilicates (layered) Mica like with $[\text{Si}_4\text{O}_{10}]^{4-}$ and related groups

VIII/H.20 - Hectorite - Zincsilite series

VIII/H.20-10 Hectorite $\text{Na}_0.3(\text{Mg},\text{Li})_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ C 2/m 2/m
 VIII/H.20-20 Saponite $(\text{Ca}/2,\text{Na})_0.3(\text{Mg},\text{Fe})_3(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ C 2/m 2/m
 VIII/H.20-27 Ferrosaponite! $\text{Ca}_0.3(\text{Fe},\text{Mg},\text{Fe})_3(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ C? Mono
 VIII/H.20-30 Spadaite $\text{MgSi}_2\text{O}_2(\text{OH})_2 \cdot (\text{H}_2\text{O})$ (?) None
 VIII/H.20-40 Stevensite $(\text{Ca}_0.5,\text{Na})_0.33(\text{Mg},\text{Fe})_3\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n(\text{H}_2\text{O})$ Unk (ORTH ?) Mono
 VIII/H.20-50 Sauconite $\text{Na}_0.3\text{Zn}_3(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ C 2/m 2/m
 VIII/H.20-60 Zincsilite $\text{Zn}_3\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot 4(\text{H}_2\text{O})$ (?) C 2/m ? 2/m

Other Hectorite Information**References:**

NAME(MinRec) PHYS. PROP.(Enc. of Minerals,2nd ed.,1990) OPTIC PROP.(Enc. of Minerals,2nd ed.,1990)

See Also:**Links to other databases for Hectorite :**

1 -Am. Min. Crystal Structure Database 2 -Athena 3 -EUROmin Project 4 -Google Images 5 -Google Scholar 6 -Handbook of Mineralogy (MinSocAm) 7 -Handbook of Mineralogy (UofA) 8 -MinDAT 9 -MinMax(Deutsch) 10 -MinMax(English) 11 -Mineralienatlas (Deutsch) 12 -QUT Mineral Atlas 13 -École des Mines de Paris

Search for Hectorite using:

Google

• Web ☐ webmineral.com

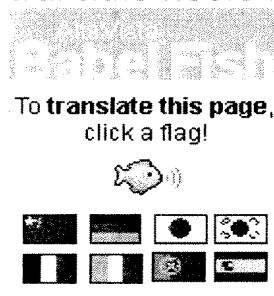
[ALTAVISTA] [AOL] [About.com] [All-The-Web] [HotBot]
 [Ixquick] [LookSmart] [MAMMA] [MSN.COM] [Netscape]
 [Teoma] [Wikipedia] [YAHOO]

Visit our Advertisers for Hectorite :

AA Mineral Specimens
 Adams Minerals
 B & L Fine Minerals
 Dakota Matrix Minerals
 Dan Weinrich Fine Minerals

[Dan Weinrich Auctions](#)
[Desert Winds Gems & Minerals](#)
[e-Rocks Mineral Auctions](#)
[Exceptional Minerals](#)
[Excalibur Mineral Company](#)
[Fabre Minerals](#)
[Greenside Minerals](#)
[John Betts Fine Minerals](#)
[Masons Minerals](#)
[Mineral Auctions - Trinity Mineral Company](#)
[Mineral News](#)
[Mineral of the Month Club](#)
[Mineralsweb - Gobin](#)
[Minernet.it Minerals](#)
[Phoenix Orion Treasures](#)
[Rockshop.cz](#)
[T G Fine Minerals](#)
[Wright's Rock Shop](#)

Translate Hectorite Mineral Data :



Ask about Hectorite here :

[Ask-A-Mineralogist from the Mineralogical Society of America](#)
[Mindat.org's Discussion Groups](#)
[Original Rockhounds Discussion Group](#)
[Rockhounds Discussion Group on Yahoo Groups](#)

Print or Cut-and-Paste your Hectorite Specimen Label here :

<p style="text-align: center;">Hectorite</p> <p> $\text{Na}_{0.3}(\text{Mg},\text{Li})_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ Dana No: 71.3.1b.4 Strunz No: VIII/H.20-10 </p> <p>Locality:</p> <p>Notes:</p>

[Print this Label](#)

HOME	CRYSTALLOGRAPHY	X-RAY TABLE	CHEMISTRY
DANA CLASSIFICATION	STRUNZ CLASSIFICATION	MINERAL PROPERTIES	A to Z LISTING
SEARCH	IMAGE LISTINGS	HELP	LINKS

Schlumberger[Products & Services](#)[About Schlumberger](#)[Investor Center](#)[Newsroom](#)[Careers](#)[Contact](#)**Oilfield Glossary**You are here: [SLB.com](#) > [Products & Services](#) > [Resources](#) > [Oilfield Glossary](#)

Search for term:

Search by discipline:

➤ More search options

Terms beginning with:

#	A	B	C	D	E	F
G	H	I	J	K	L	M
N	O	P	Q	R	S	T
U	V	W	X	Y	Z	All

Resource Links

- [Oilfield Services](#)
- [Schlumberger Excellence in Educational Development](#)
- [Oilfield Review](#)
- [Curve Mnemonic Dictionary](#)

Feedback

We welcome your suggestions and questions:

- E-mail glossary@slb.com

Credits & Bibliography

- [Contributors and references](#)

hectorite**1. n. [Drilling Fluids]**

A clay mineral similar in structure to bentonite but with more negative charges on its surface. Hectorite, made by the wet process, is a premium performance additive for use in oil-base d

See: bentonite, clay, clay, invert-emulsion oil mud, oil mud, organophilic clay, smectite

Oilfield Gl

Hectorite**Na_{0.3}(Mg, Li)₃Si₄O₁₀(OH)₂**

(c)2001 Mineral Data Publishing, version 1.2

Crystal Data: Monoclinic. *Point Group:* 2/m. As thin laths, to 2 μm , and as aggregates of such laths.

Physical Properties: *Cleavage:* {001}, perfect. *Fracture:* Uneven. Hardness = 1–2 D(meas.) = ~ 2.3 D(calc.) = n.d. Swells on addition of H₂O. Positive identification of minerals in the smectite group may need data from DTA curves, dehydration curves, and X-ray powder patterns before and after treatment by heating and with organic liquids.

Optical Properties: Translucent, transparent in thin section. *Color:* White, cream, pale brown, mottled. *Luster:* Earthy to waxy, dull.

Optical Class: Biaxial (–). $\alpha = \sim 1.49$ $\beta = 1.50$ $\gamma = 1.52$ 2V(meas.) = Small.

Cell Data: *Space Group:* C2/m. $a = 5.2$ $b = 9.16$ $c = 16.0$ $\beta = \sim 99^\circ$ $Z = \text{n.d.}$

X-ray Powder Pattern: Hector, California, USA; spacings variable by humidity, intensities variable by orientation.

4.58 (100), 1.53 (100), 15.8 (80), 2.66 (80), 1.32 (80), 1.30 (80), 2.48 (60)

Chemistry:

	(1)	(2)
SiO ₂	53.68	53.95
TiO ₂		trace
Al ₂ O ₃	0.60	0.14
Fe ₂ O ₃		0.03
MgO	25.34	25.89
CaO	0.52	0.16
Li ₂ O	1.12	1.22
Na ₂ O	3.00	3.04
K ₂ O	0.07	0.23
Cl	0.31	
H ₂ O ⁺	8.24	5.61
H ₂ O [–]	7.28	9.29
Total	100.16	99.56

(1) Hector, California, USA; corresponds to (Na_{0.42}Ca_{0.04}K_{0.01}) $\Sigma=0.47$ (Mg_{2.73}Li_{0.33}) $\Sigma=3.06$ (Si_{3.89}Al_{0.05}) $\Sigma=3.94$ O₁₀(OH)₂. (2) Do.; corresponds to (Na_{0.42}K_{0.02}Ca_{0.01}) $\Sigma=0.45$ (Mg_{2.78}Li_{0.36}) $\Sigma=3.14$ (Si_{3.89}Al_{0.01}) $\Sigma=3.90$ O₁₀(OH)₂•0.35H₂O.

Mineral Group: Smectite group.

Occurrence: In a bentonite deposit, altered from clinoptilolite derived from volcanic tuff and ash with a high glass content, related to hot spring activity (Hector, California, USA).

Association: Calcite, clinoptilolite (Hector, California, USA).

Distribution: In the USA, five km south of Hector, San Bernardino Co., California; in the Lyles deposit, 38 km northeast of Hillside, Yavapai Co., Arizona; and at Disaster Peak, in the Montana Mountains, near McDermitt, Disaster district, Humboldt Co., Nevada. From around Puy Chalard, Puy-de-Dôme, France. In the Balikesir colemanite deposit, Balikesir Province, Turkey.

Name: For the locality at Hector, California, USA.

Type Material: n.d.

References: (1) Foshag, W.F. and A.O. Woodford (1936) Bentonitic magnesian clay-mineral from California. *Amer. Mineral.*, 21, 238–244. (2) Strese, H. and U. Hofmann (1941) Synthesis of magnesium silicate gels with two-dimensional regular structure. *Zeit. anorginsche allgemeine Chemie*, 247, 65–95. (3) (1944) *Amer. Mineral.*, 29, 73 (abs. ref. 2). (4) Nagelschmidt, G. (1938) On the atomic arrangement and variability of the members of the montmorillonite group. *Mineral. Mag.*, 25, 140–155. (5) Deer, W.A., R.A. Howie, and J. Zussman (1963) Rock-forming minerals, v. 3, sheet silicates, 226–245.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without the prior written permission of Mineral Data Publishing.